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To the Graduate Council:

I am submitting herewith a thesis written by Grace Marie Hawkins entitled "Social Rhythms and Health Outcomes in Young Adults." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Nutrition.

Hollie Raynor, Major Professor

We have read this thesis and recommend its acceptance:

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(Original signatures are on file with official student records.)

Social Rhythms and Health Outcomes in Young Adults

A Thesis Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Grace Marie Hawkins

August 2020

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ABSTRACT

Background: Chronotype describes how well sleep patterns are synchronized with the overall circadian timing system (CTS). Those with a preference for Morningness have a CTS that is more optimally synchronized. A chronotype of Morningness versus Eveningness is related to more favorable dietary intake, physical activity and sleep patterns, and weight status. While chronotype is reflective of biological rhythms, as it suggests alignment with the light/dark cycle, the Social Rhythm Metric (SRM) is a measure of behavioral rhythms. The SRM assesses consistency of behavioral schedules, such as eating and physical activity, with higher scores reflecting greater consistency. While research has found that a chronotype of Morningness versus Eveningness is related to better SRM, diet, physical activity, and anthropometric outcomes, it is unknown if SRM is related to these health outcomes. Thus, it was hypothesized that in young adults a greater SRM score would be related to higher diet quality, greater physical activity, greater sleep length and efficiency, and lower anthropometric measurements.

Methods: This cross-sectional study assessed chronotype along with the independent variable of SRM and the dependent variables of diet quality, via food records, physical activity and sleep, via accelerometers, and anthropometrics. A linear hierarchical regression analyzed the relationship between SRM scores and the variables of diet, physical activity, sleep, and anthropometrics, while controlling for chronotype and gender.

Results: Complete data were collected from 59 participants, aged 18 to 34 years (mean = 22.7 ± 4.2 yrs.). The majority of participants were female (83%), never married (87%), white (71%), and not Hispanic or Latino (97%). The regression for sleep efficiency was significant (R^2 change = 0.106, $p = 0.009$). There were no significant relationships for SRM and the remaining variables of diet, physical activity, sleep, and anthropometrics.

Conclusion: Participants with greater consistency in behavioral schedules were found to have greater sleep efficiency, suggesting better synchronization of the CTS. Future research is needed in larger, more generalizable samples to better understand the relationship between SRM and health outcomes.

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CHAPTER I: LITERATURE REVIEW

BACKGROUND AND SIGNIFICANCE

Young adulthood—here defined as ages 18 through 35 years—is a time when patterns regarding health and wellness begin to be established that will carry into later adulthood (Nelson, Story, Larson, Neumark-Sztainer, & Lytle, 2008). Dietary patterns formed in young adulthood after transitioning out of adolescence stabilize and can be used to broadly predict dietary choices later in life (Dunn, Liu, Greenland, Hilner, & Jacobs, 2000). The early establishment of health patterns is further supported by national data showing declines in physical activity from the ages of 16 to 29 years, but that after the age of 30 years, physical activity level stabilizes (Caspersen, Pereira, & Curran, 2000). Weight status also tracks well from young adulthood into later adulthood (Serdula et al., 1993).

Establishing healthy eating and activity habits, as well as achieving a healthy weight status, are important for long-term health. The Dietary Guidelines for Americans 2015-2020 (DGA; U.S. Department of Health and Human Services and U.S. Department of Agriculture [USDA], 2015) describe dietary risk factors for major disease, including overweight and obesity, cardiovascular disease, diabetes, and some cancers. Dietary intake can both contribute positive effects, when a more healthful diet is consumed, and negative effects, when a less healthful diet is consumed (USDA, 2015). The Physical Activity Guidelines for Americans (Piercy et al., 2018) outlines the importance of being active for health. The risk of developing adverse health outcomes (such as cardiovascular disease, hypertension, type 2 diabetes) can be decreased by engaging in regular moderate- to vigorous-intensity physical activity. Lifelong activity can also aid in healthy aging and can reduce the fall risk of older adults (Piercy et al., 2018). Achieving and maintaining a healthy weight is helpful for reducing the risk of development of chronic disease, as overweight and obesity can increase one's risk for poorer health outcomes by

increasing risk for many diseases, such as type 2 diabetes, cardiovascular diseases, and some cancers (USDA, 2015). Therefore, behavioral patterns for diet, physical activity, and weight established in young adulthood can affect health later in the lifespan.

Factors that influence the development or maintenance of healthy and unhealthy behaviors are believed to also be important in influencing health. One such factor includes social cues. Social cues include timing cues, such as when school/work, sleep, eating, and leisure activity occur, which can establish social rhythms (Monk, Flaherty, Frank, Hoskinson, & Kupfer, 1990). Moreover, physical cues, such as the light and dark cycle, influence behavioral patterns through biological rhythms. Importantly, entrainment—or synchronization—of social and biological rhythms appear to greatly influence health via influencing the circadian timing system (Monk et al., 1990).

Circadian Timing System

The circadian timing system (CTS), as depicted in Figure 1 (Note: all Figures are found in Appendix A), is set by the master clock: the suprachiasmatic nucleus (SCN) in the hypothalamus (Salgado-Delgado, Tapia Osorio, Saderi, & Escobar, 2011). The primary input into the SCN is the light/dark cycle, which helps establish a “24-hour” circadian rhythm for the body. The SCN regulates the autonomic nervous system and hormones in the body, such as melatonin, corticosterone, and luteinizing hormone (Buijs & Kalsbeek, 2001). While the SCN is the master clock for the CTS, there are other “clocks” within the body that can influence the CTS. These other “clocks,” called peripheral oscillators (POs), are secondary to the master clock (Buijs & Kalsbeek, 2001; Stenvers, Scheer, Schrauwen, la Fleur, & Kalsbeek, 2019; Stokkan, Yamazaki, Tei, Sakaki, & Menaker, 2001). The POs work in tissues, such as the liver, white adipose tissue, brown adipose tissue, and pancreas, outside the SCN (Damiola et al., 2000;

Stokkan et al., 2001). The POs can be influenced by factors other than the light/dark cycle, including hormones and ingestion of food, to maintain rhythmicity (Stokkan et al., 2001). As several POs are located in organs important in the digestion and absorption of food, the circadian rhythms of the POs are closely tied to the temporal pattern of energy consumption (Buijs & Kalsbeek, 2001). Therefore, consistency in timing of eating during the day may assist with aligning the timing of the POs to the SCN. When the POs and the SCN are entrained, the overall CTS is synchronized, which is believed to be important for optimizing health.

Disruption to the entrainment of the CTS, called chronodisruption, can negatively impact health. Chronodisruption can be caused by sleep patterns not aligning with the light/dark input to the SCN—as is often seen with shift work (Costa, 2010)—or due to altered patterns of eating. Altered and reduced sleep has been shown to be linked to negative health outcomes (Itani, Jike, Watanabe, & Kaneita, 2017; Watson et al., 2015). Additionally, if the sleep pattern is not aligned with the light/dark cycle, it is likely that the eating patterns are also not aligned. This would cause both the SCN and the POs to become disrupted. Disruption in the entrainment of the body's CTS is associated with depression and impaired circadian rhythmicity of metabolic functions (Grandin, Alloy, & Abramson, 2006; Salgado-Delgado et al., 2011). Chronodisruption can also cause excessive drowsiness and impair alertness throughout the day (Lock, Bonetti, & Campbell, 2018). Recent research also indicates that chronodisruption over a longer period of time can lead to obesity, insulin resistance, and type 2 diabetes (Serin & Acar Tek, 2019; Stenvers et al., 2019).

This chronodisruption is also associated with gastrointestinal and cardiovascular diseases. A large-scale review by Knutsson (2003) on the effects of shift work on health outcomes and health risks found that altered bowel movements, gastrointestinal ulcers, and irritable bowel

disease are more common in shift workers than in day workers. Further, shift work has also been associated with a higher risk for myocardial infarction. Metabolic disturbances are also seen in shift workers as compared to day workers (Knutsson, 2003). It is hypothesized that these health issues arise from chronodisruption.

Chronotype

Chronotype is the timing of sleep patterns and is divided into three categories: evening-type (ET), morning-type (MT), and intermediate-type (IT; Horne & Ostberg, 1976; Lack & Bailey, 1994; Mongrain, Lavoie, Selmaoui, Paquet, & Dumont, 2004). ET is defined as late sleep paired with late waking, while MT is classified as early sleep and early waking. One's chronotype is best determined using the Composite Scale for Morningness (CSM; Diaz Morales & Sanchez-Lopez, 2004; Monk, Buysse, Potts, DeGrazia, & Kupfer, 2004; Smith, Reilly, & Midkiff, 1989), which uses quartile divisions for timing of sleep. Those in the earliest quartile for time going to bed and rising are considered MT, and those in the latest are considered ET. The middle 50% are assigned the IT chronotype. Chronotype has been shown to be reliable over a three-month (Greenwood, 1994) and thirteen-month (Caci, Nadalet, Staccini, Myquel, & Boyer, 2000) time period. However, there is limited research to indicate whether or not chronotype is malleable and can be intentionally altered. Research indicating poorer health outcomes in shift workers may suggest that chronotype is not malleable (Knutsson, 2003). Chronotype is tied to the CTS as it reflects sleep in relation to the light/dark cycle, with a MT having a pattern that should assist with better entrainment (Wright et al., 2013).

There have been observed differences with adults, aged 19-34 years, on many outcomes between those that are MT and those that are ET. Mongrain and colleagues (2005) compared 12 MT adults (mean age = 24.7 ± 1.5 years) to 12 ET adults (mean age = 23.4 ± 0.7 years) for two

days of sleep. They found that the MT people were more likely to go to bed and rise at a more consistent time than ET people (Mongrain et al., 2005). Their later research (Mongrain, Carrier, & Dumont, 2006) again compared 12 MT people and 12 ET people, aged 19-34 years.

Participants slept in the lab according to their preferred sleep schedules for two consecutive nights—with the first night allowing participants to adjust to sleeping in a lab and the second night for data collection. It was determined that ET people are more likely to vary in their sleep schedules (Mongrain et al., 2006). ET college students, aged 19-22 years, tend to sleep less each night when compared their MT counterparts, no matter if the days are work or vacations days (Yadav & Singh, 2014). These results indicate that MT is a chronotype that is better aligned to the dark/light cycle and has a more consistent sleep pattern. This suggests that MT may be better entrained than other chronotypes.

Chronotype and Diet

Chronotype has been used in research examining many different health behaviors and outcomes, one of which is eating patterns. In children, research shows that later sleep schedule—or being evening-type—is related to dietary patterns (Harrex et al., 2018). This study used data from the Physical Activity, Exercise, Diet, and Lifestyle Study on 9 to 11-year-old children from New Zealand. Data from 439 children from 17 schools included a food frequency. Instead of assessing chronotype, participants were divided into one of four sleep timing groups: early sleep/early wake; early sleep/late wake; late sleep/early wake; late sleep/late wake. The data found that children with a later sleep schedule consumed fewer fruits and vegetables and a higher consumption of sweetened beverages (fruit juice, carbonated drinks, and diet carbonated drinks; Harrex et al., 2018). Though not specifically using chronotype, the sleep patterns of the children were related to differences in dietary patterns and food choices.

Research by Fleig and Randler (2009) on 152 adolescents, aged 11-17 years (mean age = 13.2 ± 1.5 years), analyzed participant chronotype and eating patterns and behaviors. Chronotype in this study was calculated by collecting bedtimes and rise times—not sleep onset and wake times—and determining the midpoint of sleep. Diet was assessed using seven days of food logs. Diets were analyzed based on six food groupings: fast food consumption; cola and other caffeinated drinks; dairy products; sweets (such as candy, cakes, or cookies); vegetables and salad; meat. Adolescents who were MT consumed fewer caffeinated beverages and fast food compared to later chronotypes (Fleig & Randler, 2009).

Further research on adolescents and chronotype found that ET adolescents were more likely to have a higher total energy intake (Rossbach, Diederichs, Nothlings, Buyken, & Alexy, 2018). This research was done in Germany with 346 adolescents (mean age = 13.7 years) and chronotype was assessed using the Munich Chronotype Questionnaire (Roenneberg, Wirz-Justice, & Merrow, 2003). Data on diet quality were collected with three-day weighted dietary records. When using a multivariable mixed-effects regression between chronotype and daily eating patterns, there was not a direct relationship between the two. There were only daytime-specific eating patterns; the ET adolescents skipped breakfast more often, suggesting a later eating pattern, and consumed fewer carbohydrates (Rossbach et al., 2018).

In young adolescents, aged 11-13 years (mean age = 12.0 ± 0.7 years), associations were analyzed between chronotype, body mass index (BMI), and dietary patterns (Arora & Taheri, 2015). Chronotype was determined using an adjusted version of the Morningness-Eveningness Questionnaire (MEQ; Horne & Ostberg, 1976). Food frequencies were also done via interview questions to assess for average consumption of unhealthy snack foods (cookies, chocolate, sweets, cake, etc.) and caffeinated beverages (tea, coffee, or carbonated beverages). The

adolescents were asked how often (daily, almost daily, sometimes/rarely) they consumed unhealthy snacks, or how often (never, sometimes, usually/always) they consumed caffeinated beverages before they go to bed. The participants were also asked about how many fruits and vegetables they ate each day. Having a later chronotype was associated with consumption of unhealthy snacks and caffeine at night. Further, those with a preference for Eveningness had a greater likelihood of consuming an inadequate level of fruits and vegetables (Arora & Taheri, 2015).

Chronotype and food patterns have not been widely explored in young adults but have been explored in various other populations. When looking at 100 pregnant women (mean age = 27.3 ± 5.7), chronotype was calculated by using mid-sleep time on free days (days with no morning obligations; Gontijo et al., 2018). Three 24-hour dietary recalls were conducted to collect data on diet, and the quality of the diet was assessed using the revised and validated Brazilian Healthy Eating Index (BHEI-R). The BHEI-R scores were on average higher, indicating a higher quality diet, when there was an earlier chronotype and consumption of a first meal—breakfast (Gontijo et al., 2018).

Another study with 245 pregnant women, aged 19-35 years, compared chronotype to early gestational weight gain and food cravings (Teixeira et al., 2019). Chronotype was calculated by using mid-sleep time on free days. Food cravings were assessed using two questionnaires: Food Craving Questionnaire Trait and Food Craving Questionnaire State. The Food Craving Questionnaire Trait assesses for the intensity of food cravings over long periods of time and in different situations that are then considered trait cravings—rather than cravings initiated by a state, like stress, as is assessed in the Food Craving Questionnaire State. Results showed that women who were ET were more likely to have trait food cravings compared to both

MT and IT women. This also led to greater weight gain in the early gestational period (Teixeira et al., 2019). Therefore, chronotype was shown to be related to food cravings and not just food intake and patterns.

In a case-control study on adults, aged 20-85 years, with prostate or breast cancer, interviews were conducted with 4,019 participants (1,205 breast cases, 621 prostate cases, 1,321 women controls and 872 men controls; Kogevinas et al., 2018). The Munich Chronotype Questionnaire (Roenneberg et al., 2003) was used to calculate chronotype and average diet was assessed through a 140-item food frequency questionnaire. Morningness was associated with a greater period of time between dinner consumption and sleep onset, and this extended time of more than an hour was seen to be protective against both cancers (Kogevinas et al., 2018).

In a longitudinal study done in Finland, 1,097 adult participants, aged 25-74 years, were assessed on chronotype, dietary patterns, and weight over seven years (Maukonen, Kanerva, Partonen, & Mannisto, 2019). Participants were assessed for chronotype using the shortened MEQ, and 50% were MT, 40% were IT, and 10% were ET. This study found that participants who consumed most of the calories in the evening were more likely to be obese at follow-up and that chronotype did not affect this relationship (Maukonen et al., 2019).

The relationship between diet and eating patterns and chronotype has been well established in many different populations. Those that are MT are more likely to consume a diet that has healthier qualities, such as lower intake of caffeinated and sweetened beverages, fast food, and unhealthy snacks, and higher intakes of fruits and vegetables along with an overall healthy diet (Arora & Taheri, 2015; Fleig & Randler, 2009; Gontijo et al., 2018; Harrex et al., 2018; Kogevinas et al., 2018; Rossbach et al., 2018).

Chronotype and Physical Activity

Chronotype has also been related to physical activity. In children, research shows that later sleep schedule—or being evening-type—is inversely related to physical activity (Harrex et al., 2018). As reported previously, this study used data from the Physical Activity, Exercise, Diet, and Lifestyle Study on 9 to 11-year-old children from New Zealand. Data were collected from 439 children from 17 schools; the participants completed a physical activity questionnaire and wore a wrist accelerometer. Participants were divided into one of four sleep timing groups. A later sleep schedule was found to be related to lower levels of activity (Harrex et al., 2018).

Adolescent research has found that being ET is correlated to almost half an hour less of moderate-to-vigorous physical activity daily compared to sociodemographic-matched MT adolescents (Olds, Maher, & Matricciani, 2011). This study included 2,200 adolescents, aged 9 to 16 years, in Australia, and the participants gave information on sleep and wake times (also divided into four groups: early sleep/early wake; early sleep/late wake; late sleep/early wake; late sleep/late wake) and completed the Multimedia Activity Recall for Children and Adults to assess moderate-to-vigorous physical activity. ET (late sleep/late wake) adolescents engaged in less moderate-to-vigorous and vigorous physical activity, less free play and sport play, and fewer steps than MT (early sleep/early wake) adolescents (Olds et al., 2011).

In adults, it appears that having a later chronotype is associated with lower levels of physical activity, when length of sleep is controlled for (Shechter & St-Onge, 2014). This retrospective study looked at 22 adults, aged 30 to 45 years, with a BMI indicating a healthy weight or having overweight. Physical activity was collected using an ActiGraph accelerometer. Chronotype was determined using the MEQ. Timing of the sleep schedule was statistically significantly related to physical activity level, when controlling for age, sex, BMI, and total sleep

time. Those who were considered ET were more likely to have been more sedentary and to have engaged in less physical activity—both light and moderate-to-vigorous (Shechter & St-Onge, 2014).

Chronotype is related to levels of physical activity in many age groups, and the trends indicate that those with an earlier chronotype are more likely to engage in physical activity (Harrex et al., 2018; Olds et al., 2011; Shechter & St-Onge, 2014). However, the research on chronotype and physical activity has mostly been conducted with children and adolescents.

Chronotype and Weight Regulation

Chronotype is not only related to diet and physical activity, but also to weight status. In a study by Ross and colleagues (2016), participants with an average age of 56 years (± 10.4 years) in two weight loss interventions were compared to people in the National Weight Control Registry (NWCR), mean age of 52 years (± 12.5 years). Chronotype of all participants was assessed using the MEQ. People in the NWCR had higher scores on the MEQ than those in the interventions; more people in the NWCR were MT than in the interventions (Ross et al., 2016). However, this study was unable to determine the direction of the correlation. It is unclear if the chronotype predicted better weight loss maintenance or if weight loss maintenance led to a predisposition to Morningness.

One study followed patients after bariatric surgery to assess for weight loss and chronotype (Ruiz-Lozano et al., 2016). Two hundred and fifty-two participants with a mean age of 52 years (± 11 years) were studied after undergoing bariatric surgery. Chronotype was determined using the shortened MEQ (Horne & Ostberg, 1976). Data on weight were collected at 12, 18, 24, 36, 48, 60, and 72 months after the surgery. Participants who were ET were more likely to have a higher BMI prior to the surgery compared to MT participants. Overtime, ET

participants showed less weight loss, reported as percent of original body weight even when controlling for gender, age, body weight at baseline and type of surgery. After four years post-surgery, ET people were more likely to regain weight (Ruiz-Lozano et al., 2016). This suggests that chronotype may be a predictor for weight loss and response to bariatric surgery.

In the aforementioned study by Arora and Taheri (2015), young adolescents with a later chronotype were more likely to also have a higher zBMI score. As discussed previously, this was also related to dietary factors. The greater the preference for Eveningness, the higher the zBMI score of the young adolescents (Arora & Taheri, 2015).

In college freshmen, one study showed that ET students were more likely to gain weight when starting college (Culnan, Kloss, & Grandner, 2013). One hundred and thirty-seven college freshmen (mean age = 18.3 years) completed the shortened MEQ (Horne & Ostberg, 1976) and demographic information used to calculate BMI. Fifty-four participants also completed the follow-up questionnaire 8 weeks later. Due to lower response rates, MT participants were combined with IT participants. ET students were more likely to gain weight over the 8 weeks of the study, when controlling for sex; there were no differences in BMI across chronotype at baseline (Culnan et al., 2013).

In a Finnish longitudinal study, 1,097 adult participants, aged 25-74 years, were assessed on chronotype and weight over seven years (Maukonen et al., 2019). Participants were assessed for chronotype using the shortened MEQ (Horne & Ostberg, 1976), and 50% were MT, 40% were IT, and 10% were ET. Female participants who were ET gained statistically significantly more weight over the course of the 7 years, but this association became non-significant after excluding participants diagnosed with depression (Maukonen et al., 2019).

Chronotype may be important to consider when attempting weight loss. A recent randomized clinical trial compared a typical hypocaloric diet to a chronotype-adjusted hypocaloric diet that tailored the distribution of calories dependent upon the participants' chronotype (Galindo Munoz et al., 2019). In this trial, 200 participants, aged 18-65 years, that had either overweight or obesity were prescribed hypocaloric diets of 1,600-2,000 kilocalories (kcal) for men and 1,000-1,500 kcal for women across five eating occasions. The intervention was in the distribution of the calories throughout the day. The control caloric distribution was as follows: breakfast 20%, midmorning 10%, lunch 35%; mid-afternoon 10% and dinner 25%. Those in the intervention group who were MT had a larger breakfast and had a caloric distribution of: breakfast 30%, midmorning 10%, lunch 35%; mid-afternoon 5% and dinner 20%. Those in the intervention group who were ET consumed a larger dinner and had a caloric distribution of: breakfast 20%, mid-morning 5%, lunch 35%; midafternoon 10% and dinner 30%. Both the control group and the intervention group lost weight—due to the hypocaloric diet; however, those that received a chronotype-adjusted diet lost more weight over the course of the 12-week intervention. At a 12-month follow up, the differences remained significant. Interestingly, there was no difference in the amount of weight loss between the MT and ET participants in the intervention group (Galindo Munoz et al., 2019).

Overall, chronotype has been shown to be related to weight status (Arora & Taheri, 2015; Culnan et al., 2013; Galindo Munoz et al., 2019; Maukonen et al., 2019; Ross et al., 2016; Ruiz-Lozano et al., 2016). MT people tend to have better outcomes related to weight management. This may be due to the differences in dietary factors and physical activity levels as described previously. However, when attempting weight loss, it may be beneficial to adjust the caloric

distribution to best match one's chronotype (Galindo Munoz et al., 2019). This adjustment will likely aid in the entrainment of the CTS and POs.

Social Rhythm Metric (SRM)

While chronotype is reflective of biological rhythms, the Social Rhythm Metric (SRM), developed by Monk and colleagues (1991), is a validated measure of the consistency in a person's daily routine, or social rhythms. Participants complete the SRM by filling out a log detailing when they completed 17 habitual activities (such as "get out of bed" and "have dinner,") over the course of the week. If an activity is done at least three times in a week, then it is included in the analyses. The average time of each activity is calculated and termed the 'habitual time'. Each time an activity is completed within 45 minutes of the habitual time, a "hit" is generated. For each activity, the highest score could be a 7. These hits are summed and averaged, producing an SRM score. These scores can range from 0 to 7, with a higher number indicating a greater regularity and consistency in that person's behavioral schedule.

The SRM is considered to be a robust indicator of social rhythms and scores tend to lie in a normal distribution (Schimitt et al., 2010; van Tienoven et al., 2014). The scores of the SRM have been shown to be consistent over a 12-week period for adults, aged 21-65 years (Monk et al., 1991). Additionally, a validation study showed that high SRM scores are statistically significantly associated with lower levels of psychological distress as reported on the 12-item version of the General Health Questionnaire by 1,249 adults, aged 25-65 ($b = -2.570$, $P < 0.010$; van Tienoven et al., 2014). Test-retest reliability for the SRM is adequate for adults, aged 20-40 years ($r = 0.48$, $P < 0.008$; Monk, Petrie, Hayes, & Kupfer, 1994). Research is inconclusive on the gender differences in SRM scores, with some research indicating that males score on average 0.4 units higher than females, indicating a more regular schedule (Monk, Reynolds, Buysse,

DeGrazia, & Kupfer, 2003). The SRM can be used to categorize those whose scores fall one standard deviation below the mean of the group as ‘irregular’ type.

Age has been seen as a factor for influencing SRM scores, such that as people age, they are more likely to have an increase in their SRM scores (Monk et al., 1997). This follows since young adults and college students are less likely to be consistent in their daily lives compared to older adults who work jobs with regular hours. Therefore, it is expected that college students and young adults would have lower SRM scores.

SRM and Sleep

The CTS links to the light/dark cycle to set the master clock within the body (Salgado-Delgado et al., 2011). If sleep schedules do not align with the natural light/dark cycle, then the SCN is exposed to more artificial light, which inhibits the ability of the SCN to sync appropriately. This disruption in sleep can be attributed to the SCN’s regulation of melatonin and may be the main cause of chronodisruption (Buijs & Kalsbeek, 2001; Salgado-Delgado et al., 2011). When sleep cycles cause chronodisruption, this causes further issues by limiting the metabolic efficiency due to poor entrainment of POs to the SCN (McHill & Wright, 2017). Thus, poor sleep is an indicator of chronodisruption.

For sleep, there is a significant relationship for adults, aged 19-49 years ($\rho = -0.4$, $P < 0.001$; mean age = 31.2 years \pm 7.8 years; Monk et al., 2003) between the SRM scores and scores on the Pittsburg Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989)—a gold standard test for sleep quality (Monk et al., 2003). The PSQI assesses the frequency of poor sleep indicators, and so a higher score denotes poorer sleep. Those with lower SRM scores, indicating less behavioral consistency, had higher occurrences of poor sleep indicators, or poorer sleep (Monk et al., 2003). Because poor sleep is related to both

chronodisruption and SRM scores, it is possible that less consistent social rhythms, or lower SRM scores, are related to chronodisruption. If so, it would be anticipated that lower SRM scores would be related to other poor indicators of health, such as dietary intake, physical activity levels, and weight status. This has not been examined previously.

Importantly, SRM and chronotype are related. There have been significant differences on SRM between groups—higher scores in MT people, suggesting entrainment of the CTS (Monk et al., 2004). One study with adults, aged 20-59 years, compared SRM scores and scores on the Composite Scale for Morningness and found that those with a preference for Morningness had higher SRM scores ($F(2,97) = 10.768$; $P < 0.001$; Monk et al., 2004). There is also a moderate correlation between SRM and Composite Scale for Morningness scores ($r = -0.437$, $P < 0.001$; Monk et al., 2004).

Another study used chronotype along with SRM and found that ET college student workers indicated lower sleep quality and lower SRM scores than those that were IT or MT (Martin, Hébert, Ledoux, Gaudreault, & Laberge, 2012). The average age of the participants was 20.2 years (± 0.4 years). Further, this study found that ET students were exposed to lower levels of light during the day and to more light at night compared to both MT and IT students. Because light exposure is linked to circadian entrainment, being ET and having lower levels of light exposure during the day could lead to chronodisruption (Martin et al., 2012).

Previous research shows that chronotype is related to scores on the SRM (Monk et al., 2004), with MT more likely to go to bed and rise at a more consistent time (Mongrain et al., 2005). Both chronotype and the SRM are related to sleep and sleep patterns; however, the SRM includes other activities in its scoring beyond just sleep (such as meal timings). Thus, while chronotype may be more representative of biological circadian rhythm set by the light/dark

cycle, SRM is more representative of behavioral rhythms set by social cues. While research has examined chronotype, a marker for biological circadian rhythm, and health outcomes, little research has been conducted regarding behavioral rhythms, which can be measured by the SRM and can also influence the CTS, and health.

CHAPTER II: MANUSCRIPT

INTRODUCTION

The circadian timing system (CTS) in humans ensures adaptation to the 24-hour day/night light and dark cycle by generating the 24-hour rhythms (circadian rhythms) found in biological and behavioral functions (Richter et al., 2004). The CTS is set by the master clock: the suprachiasmatic nucleus (SCN) in the hypothalamus (Salgado-Delgado et al., 2011). The SCN is entrained, or synchronized, by the daily light-dark cycle. There are other clocks within the body that can influence the CTS, called peripheral oscillators (POs; Buijs & Kalsbeek, 2001; Stenvers et al., 2019; Stokkan et al., 2001). The POs work in tissues outside the SCN, such as the liver (Damiola et al., 2000; Stokkan et al., 2001). The POs can be influenced by hormones and ingestion of food and use the timing of eating to maintain rhythmicity (Stokkan et al., 2001). When the POs and the SCN are synchronized, the overall CTS is entrained, which is believed to be important for optimizing health.

When the SCN and POs are not entrained, chronodisruption occurs and can negatively impact health by impairing metabolic functions and causing excessive drowsiness (Grandin et al., 2006; Lock et al., 2018; Salgado-Delgado et al., 2011). Recent research also indicates that chronodisruption over a longer period of time can lead to chronic health conditions, such as obesity and type 2 diabetes (Serin & Acar Tek, 2019; Stenvers et al., 2019). Interestingly, metabolic disturbances are seen in shift workers as compared to day workers (Knutsson, 2003), and it is hypothesized that these health issues arise from chronodisruption in shift workers.

Sleep patterns are central to the entrainment of the CTS because sleep patterns determine alignment, or lack thereof, to the light/dark cycles of the day and are markers of biological rhythms. There are many ways to classify sleep patterns, with one highly validated method being chronotype. Chronotype is divided into three categories: evening-type (ET), morning-type (MT),

and intermediate-type (IT; Horne & Ostberg, 1976; Lack & Bailey, 1994; Mongrain et al., 2004). ET is defined as late sleep paired with late waking, while MT is classified as early sleep and early waking. Chronotype is tied to the CTS as it reflects sleep in relation to the light/dark cycle (Wright et al., 2013). Research shows that MT young adults are more likely to sleep at a more consistent time than ET young adults (Mongrain et al., 2005), and ET young adults are more likely to vary in their sleep schedules (Mongrain et al., 2006). ET college students tend to sleep less each night when compared to their MT counterparts (Yadav & Singh, 2014). These results suggest that MT may be better entrained to the light/dark cycle than other chronotypes.

The relationship between chronotype and differing health patterns, such as eating patterns, has been previously examined (Arora & Taheri, 2015; Fleig & Randler, 2009; Gontijo et al., 2018; Harrex et al., 2018; Rossbach et al., 2018; Teixeira et al., 2019). Research shows that those with a greater preference for Eveningness have a lower diet quality (Arora & Taheri, 2015; Fleig & Randler, 2009; Gontijo et al., 2018; Harrex et al., 2018; Teixeira et al., 2019) and consume more calories than those with an earlier chronotype (Rossbach et al., 2018). Chronotype is also related to levels of physical activity in many age groups, indicating that those with a later chronotype are more inactive than others with an earlier or intermediate chronotype (Harrex et al., 2018; Olds et al., 2011; Shechter & St-Onge, 2014). Further, chronotype has been shown to be related to weight status. Research indicated that ET people had poorer outcomes related to weight management following bariatric surgery than those who were MT (Ruiz-Lozano et al., 2016); other research shows that ET people are more likely to have a higher BMI (Culnan et al., 2013; Ross et al., 2016). Overall, chronotype has been shown to be related to health outcomes such that a later chronotype leads to poorer outcomes.

While chronotype is reflective of biological rhythms as it reflects alignment with the light/dark cycle, the Social Rhythm Metric (SRM), developed by Monk et al. (1991), is a validated measure of the consistency in a person's daily routine, or behavioral rhythms. SRM scores range from 0 to 7, with a higher number indicating a greater regularity and consistency in that person's schedule. The SRM is considered to be a robust and normal indicator of social rhythms (Schimitt et al., 2010; van Tienoven et al., 2014). SRM scores have been shown to be consistent over the short term (Monk et al., 1991). Age has been seen as a factor for influencing SRM scores, such that as people age, they are more likely to have an increase in their SRM scores (Monk et al., 1997).

Importantly, SRM and chronotype are related. There have been significant differences in SRM between chronotype groups, with higher SRM scores in MT people and lower SRM scores in ET, suggesting entrainment of the CTS, in both biological and behavioral rhythms, in those with higher SRM scores (Monk et al., 2004). Another study assessed chronotype along with SRM and found that ET college student workers indicated lower sleep quality and lower SRM scores than those that were IT or MT (Martin et al., 2012). Thus, while research has examined the relationship between chronotype, which is reflective of biological rhythms, and health behaviors and outcomes, little research has been conducted regarding behavioral rhythms, which can be measured by the SRM and can also influence the CTS, and health.

Due to the relationship between SRM and chronotype; and chronotype and diet, physical activity, and weight status, it would be anticipated that SRM is also related to these health outcomes. Specifically, it would be anticipated that more consistent behavioral social rhythms (higher SRM) would be related to a healthier eating pattern, greater physical activity, and better weight management. Therefore, to better understand how social rhythms are related to health,

this investigation will be measuring SRM, diet quality, physical activity, sleep, and anthropometrics. The population of interest for this study is young adults because this is a critical time when behavioral patterns that will be carried into adulthood are being established (Nelson et al., 2008). It was hypothesized that greater consistency in a young adult's behavioral pattern, higher SRM score, would be related to better health outcomes, such as higher diet quality, greater physical activity, greater sleep length and efficiency, and lower anthropometrics.

STUDY DESIGN AND METHODOLOGY

Design and Overview

To see if consistency in a young adult's behavioral pattern is related to diet quality, physical activity, sleep, and weight, an observational, cross-sectional study was conducted.

Participants

Participants, aged 18 to 35 years, were recruited from the University of Tennessee, Knoxville campus and the surrounding area via flyers hung up and handed out throughout the area. Flyers indicated that this study was collecting information on young adults' diet, physical activity, and sleep habits. The researcher used University electronic mailing lists and announcements in Nutrition 100 courses to pass the flyer and information on to students.

There were no exclusion criteria for race/ethnicity, gender, or weight status for the study. However, participants with dietary restrictions for medical reasons (i.e., phenylketonuria diet) were excluded. This was to ensure generalizability to populations of free-eating people. Those with dietary restrictions such as vegetarianism, veganism, or food allergies were included because these dietary restrictions do not inherently indicate a higher or lower diet quality. Participants had to pass the Physical Activity Readiness Questionnaire for Everyone (PAR-Q+; Warburton, Jamnik, Bredin, & Gledhill, 2011), indicating that they are able to engage in physical

activity without the need for physician approval. Participants who were pregnant were excluded. The armband provided to collect physical activity and sleep data contained stainless steel, and so participants allergic to stainless steel were excluded from participating. Participants were required to have access to an email address and internet each day during their participation to complete the SRM metric via an online survey. Participants were required to be in town when all measures are collected. Participants were required to be taking classes and/or working a job when all measures were collected; this was to ensure activities during participation reflected their typical schedule, i.e. not on school breaks. However, those that were shift workers were excluded, because the CTS in shift workers does not align with the light/dark cycles. Shift work was defined as having to work a shift for any period of time between the hours of 12am and 6am.

All participants were given a \$25 gift card after their participation as compensation. They were only eligible for the gift card after completing all questionnaires and measures administered.

Procedures

Following a phone screen, all eligible participants scheduled a time to come into the Healthy Eating and Activity Laboratory (HEAL) at the University of Tennessee, Knoxville for their first, baseline appointment. At the first appointment, the second, final appointment was scheduled. These appointments were required to be at least eight days—but no more than 14 days—apart allowing for a full week between sessions for the participants to complete the SRM. See Figure 2 for participant flow through the study.

Baseline assessments could occur on any day of the week that worked for the participant. It was at this appointment that informed consent was obtained. See Appendix B for the consent form. After obtaining consent, height was collected using a stadiometer, and weight and body

composition were collected via bioelectrical impedance. Next, the participant completed the demographic questionnaire and the Composite Scale for Morningness. Participants were given a BodyMedia Armband along with instructions for care and use and a charging cord. Participants were instructed to start wearing the armband after waking the next day, and to wear it day and night over the course of the coming week until they returned for their second and final appointment. They were told to not wear the armband while bathing or swimming, as the device was not waterproof. Participants received instructions on how to complete the SRM via Question Pro over the course of their participation.

Participants were given materials for the food records: two-dimensional visual aids and a booklet with lines for each food item. These aids were to assist in collecting the most accurate dietary information as possible. These food records were collected over three successive days; one of the days was a weekend day and two were weekdays (either Thursday, Friday, and Saturday or Sunday, Monday, and Tuesday). Participants were instructed on how to record a detailed and accurate food record by recording food as it is being eaten with as much detail as possible. The food records were reviewed at the second appointment in order to add more detail as was necessary.

The second and final appointment took place in the HEAL. Should the participant have been menstruating during the first session, body composition was assessed during the second session. Participants returned the armband and charging cord; data were downloaded from the armband and verified for sufficient wear time. Participants were asked if their previous week of participation reflected a ‘normal’ or ‘typical’ week for them. Food records were reviewed to ensure thorough information on all food. Once all data were collected, participants were eligible for the gift card. A summary of data from the food records was compiled along with physical

activity and sleep patterns and was provided to participants via email within two weeks of their final session.

Measures

Demographics. Participants completed a demographics questionnaire regarding their gender, age, level of current education, marital status, racial heritage, and ethnic heritage. This was collected during the first appointment.

Social Rhythm Metric. The SRM (Monk et al., 1991) measures the consistency in a person's daily routine. Participants completed the SRM by filling out a log detailing when they completed 17 habitual activities (such as "get out of bed" and "have dinner,") over the course of the week. If an activity was done at least three times in a week, then it was included in the analyses. The average time of each activity was calculated and termed the 'habitual time.' Each time an activity was completed within 45 minutes of the habitual time, a "hit" was generated. For each activity, the highest score could be a 7. These hits were summed and averaged, producing an SRM score. These scores range from 0 to 7 and, with a higher number indicating a greater regularity and consistency in that person's schedule. Each morning, participants received an email with a link for their entry of the SRM metrics via Question Pro. See the full questionnaire in Appendix D. Participants were required to fill out the SRM survey for the previous day by 3 pm at the latest. If a participant did not complete the survey by 2 pm, then they received a reminder email. If a participant neglected to complete the survey by 3 pm, then they were emailed once again in order to get a survey response.

Chronotype. Chronotype was assessed using the CSM (Smith et al., 1989). This scale was created by combining the Morningness-Eveningness Questionnaire (Horne & Ostberg, 1976) and a diurnal scale by Torsvall and Akerstedt (Torsvall & Akerstedt, 1980) based on factor

analyses in order to make a more accessible and comprehensive chronotype measure (Shahid, 2012). The CSM contains 13 questions with scores on each question ranging from 1 to 4 or 5; see Appendix E for the questionnaire. The scores on all questions are totaled, and a higher CSM score indicated a preference for Morningness. A score of 22 or less indicates that the person is evening-type, more than 44 indicates morning-type, and between these cutoffs indicates intermediate-type. Scores on the CSM have been shown to be normal when tested with young adults (Diaz Morales & Sanchez-Lopez, 2004). The CSM has good test-retest reliability, and the Cronbach α for the CSM was 0.90 (Bohle, Tilley, & Brown, 2001).

Dietary Assessment. Three successive daily food records were collected. Though not always reliable due to human error (Trabulsi & Schoeller, 2001), food records are considered to be a top, standard method for collecting dietary information (Biro, Hulshof, Ovesen, & Amorim Cruz, 2002). Food records do not rely on the memory of participants, which is the case for 24-hour food recalls. Further, because the food records are open ended, participants are less likely to omit food or drinks consumed (Biro et al., 2002). Food records were collected over three days, with one being a weekend day in order to get the best representation of the participant's overall diet (Biro et al., 2002).

Intake based on the food records was entered into the Nutrition Data System Software for Research (NDSR). Data on both foods and beverages consumed were of interest. Using the data from NDSR, a score was generated for the average Healthy Eating Index-2015 (HEI; Krebs-Smith et al., 2018) for each participant based on the three food records. The HEI assesses the diet of an individual compared to the recommendations from the Dietary Guidelines for Americans 2015-2020 (DGA; USDA, 2015). A score is generated from 0 to 100, with a diet scoring 100 meeting all recommendations by the DGA for all components. Total energy intake (kcal) across

the three days of food records were also assessed. Both HEI score and total energy intake were used in analysis.

Accelerometry. BodyMedia SenseWear Armbands were worn by participants during the day and at night to collect data on physical activity level and sleep patterns. These Armbands have been shown to be valid and reliable in rest and activity measures in a laboratory setting when compared to indirect calorimetry energy expenditure (Fruin & Rankin, 2004). However, the accuracy of the BodyMedia Armband for energy expenditure in free-living conditions is still limited, but this limitation exists for all accelerometers when comparing laboratory activity to free-living activity. Research has compared the sleep capabilities of the BodyMedia Armband to overnight sleep study polysomnography (Sharif & Bahammam, 2013). Results show no observed differences in the data from the BodyMedia Armband and overnight sleep study polysomnography (Sharif & Bahammam, 2013).

The BodyMedia Armband provides data on total energy expenditure from all levels of physical activity and minutes of physical activity based on intensity (light, moderate, vigorous, very vigorous). Average energy expenditure from physical activity and minutes of at least moderate-intensity physical activity (MVPA, based on the Physical Activity Guidelines for Americans) were used in analysis. The BodyMedia Armband also provides the length of sleep along with sleep efficiency, and both were used in analysis.

Anthropometrics. Height was assessed with a stadiometer. Weight, BMI (kg/m^2), and body fat percentage (BF%) were assessed by the TANITA Body Composition Analyzer TBF-300. Participants were instructed to remove socks, shoes, bulky jackets and outerwear, and items in their pockets during weight and height collection. Body composition was assessed using bioelectrical impedance.

The foot-to-foot bioelectrical impedance has been compared to dual-energy X-ray absorptiometry (DXA), the standard for measuring body composition (Goldfield et al., 2006). BF% calculated via bioelectrical impedance was highly correlated to that from the DXA. There were no statistically significant differences between the assessments, but the bioelectrical impedance tended to underestimate BF% and fat mass while overestimating fat-free mass (Goldfield et al., 2006). The test-retest reliability of the BF% calculated via bioelectrical impedance was high (Vasold, Parks, Phelan, Pontifex, & Pivarnik, 2019).

In order to assess body composition via BF% accurately, all participants were required to adhere the following bioelectrical impedance guidelines: 1) to not consume alcohol within 12 hours of the assessment, 2) to not engage in excessive or very vigorous exercise within 12 hours of the assessment, 3) to not excessively eat or drink within 24 hours of the assessment, 4) to not eat or drink within 3 hours of the assessment, 5) to urinate within 30 min of the test, and 6) to avoid assessment of female participants during menstruation. When a participant was menstruating during the first session, BF% was instead collected at the second session. Both BMI and BF% were used in analysis.

Statistical Analyses

Data were analyzed using SPSS version 25.0 with an alpha of ≤ 0.05 . The demographic data were analyzed with descriptive statistics to report on the overall sample. A logistical hierarchical regression was used to analyze the relationship between SRM and chronotype, with gender force entered into the first block. Pearson correlations were conducted for SRM scores and all variables of diet, physical activity, sleep, and anthropometrics

A linear hierarchical regression was used to analyze the relationship between SRM scores and the variables of diet, physical activity, sleep, and anthropometrics. For all analyses,

chronotype and gender were force entered into the first block, with the SRM score entered into the second block. Individual regressions were conducted for each dependent variable (HEI score, total energy intake, energy expenditure from physical activity, minutes of at least MVPA, sleep efficiency, length of sleep, BMI, and BF%). Bonferroni corrections were used for all analyses of food intake, physical activity, sleep, and weight, due to each of these dependent variables having more than one measure. For example, weight had two analyses conducted, BMI and BF%. For all analyses, the Bonferroni corrections resulted in an alpha of ≤ 0.025 .

RESULTS

Consent was collected from 63 participants; however, three participants dropped out of the study between appointments one and two. A fourth participant completed the activities, but armband data were corrupted and could not be obtained from the BodyMedia Armband. Therefore, complete data were collected from 59 participants. With a small effect size of 0.15, having 59 participants provided power equal to 0.44. Participants ranged in age from 18 to 34 years (mean = 22.7 ± 4.2). The majority of participants were female (83%), never married (87%), white (71%), and not Hispanic or Latino (97%). The current level of education varied widely. Full participant demographics can be found in Table 1 (Note: all Tables are found in Appendix C). At the second appointment, 47 participants (79.7%) stated that the previous week was a normal week for them.

For chronotype, there were 4 MT participants and 55 IT, meaning that no participants were ET. The mean score on the CSM (chronotype measure) was 36.3 ± 6.1 , and scores ranged from 25 to 49. Scores on the SRM ranged from 1.5 to 5.2 (mean = 3.1 ± 0.9). The average time the SRM survey was completed was 7:26 am. There were 17 instances where participants had to be emailed again to complete the survey after 3:00 pm. Of these 17 instances, two people had to

be emailed on one day, one had to be emailed on two days, one had to be emailed on 6 days, and one had to be emailed on 7 days.

The data for health outcome variables of diet, physical activity, sleep patterns, and weight status were normally distributed with means shown in Table 2. HEI scores ranged from 26.9 to 78.4 while the average energy intake ranged from 704 kcal to 3,917 kcal per day. The average daily wear time for the BodyMedia Armband was 23 hours and 19 minutes. Physical activity varied greatly with average energy expenditure from physical activity ranging from 193.1 to 2,539.7 kcal and average minutes of MVPA ranging from 17 minutes to 262 minutes. The average sleep efficiency was varied from 59.3% to 91.5%, and the length of sleep was between 4.3 hours and 10.7 hours. The BMI of participants ranged from 16.7 kg/m² to 36.8 kg/m²; BF% of participants ranged from 3.1% to 45.3%.

A logistical hierarchical regression was used to analyze the relationship between SRM and chronotype, with gender force entered into the first block. There was a significant relationship between the two variables, such that those with greater consistency in behavioral schedule (higher SRM score) had a greater preference for Morningness (CSM). The regression equation was significant ($F(2,56) = 3.532, p = 0.036$), with a significant R^2 change of 0.082 ($p = 0.029$).

The regression statistics for the health outcome variables can be found in Table 3, and Pearson correlations can be found in Table 4. For sleep efficiency, the regression equation was significant ($F(3,55) = 5.021, p = 0.004$), with a significant R^2 change of 0.106 ($p = 0.009$). The greater the consistency in one's schedule (SRM score), the higher the sleep efficiency. For every one-point increase in SRM score, the sleep efficiency increased by 3.14%. No other models were significant.

DISCUSSION

The purpose of this study was to determine if the consistency in a young adult's behavioral schedule was related to diet, physical activity, sleep patterns, and weight status. It was hypothesized that those with greater consistency in behavioral schedule, as determined by the SRM score, would have greater diet quality, physical activity level, sleep quality, and lower anthropometrics.

For this study's sample of young adults, scores on the SRM were significantly correlated to chronotype. Those with a greater preference for Morningness had greater consistency in behavioral social rhythms. This is aligned with and contributes to previous research that demonstrated that MT people are more likely to have greater SRM scores, which suggests entrainment of the CTS (Monk et al., 2004). Research shows a moderate correlation between SRM and CSM scores ($r = -0.437$, $P < 0.001$; Monk et al., 2004).

For SRM and health variables, sleep efficiency was the only health variable found to be significantly related to SRM score, with the greater the consistency in behavioral schedule, the higher the sleep efficiency. This finding aligns with previously conducted research. Previous research that looked at sleep quality, and not sleep efficiency specifically, along with SRM found that people with lower SRM scores had poorer sleep quality (Monk et al., 2003). For this previous research, sleep quality was assessed using a self-report questionnaire, the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989), that assesses seven components of sleep quality, one of which is sleep efficiency within the past month (Monk et al., 2003). Other previous research in college student workers found that ET participants indicated lower sleep quality via the PSQI and lower SRM scores than those that were IT or MT (Martin et al., 2012); the SRM scores and sleep quality were related. For the current study, sleep efficiency was calculated to be

the percentage of time in bed that the participant was asleep. While the two measures of sleep quality and sleep efficiency are not identical, they capture similar behaviors. Therefore, this current study concurs with and expands upon the previous research that greater consistency in sleep schedule is related to better sleep, both in quality and efficiency.

The health variable of BMI did not reach significance with an effect size of 0.038, but there was a trend indicating that those with a greater consistency in behavioral social rhythms were more likely to have a lower BMI. This trend is in the hypothesized direction. While previous research has not analyzed the relationship between weight status and SRM scores, research examining the relationship between chronotype, which is related to SRM in previous studies and in the current study, and BMI has been conducted. As previously discussed, research that followed patients after bariatric surgery found that those that were ET had poorer weight outcomes than those that were MT (Ruiz-Lozano et al., 2016). Research with young adolescents determined that those with a later chronotype were more likely to have a higher zBMI score (Arora & Taheri, 2015). In college freshmen, one study showed that ET students were more likely to gain weight when starting college (Culnan et al., 2013). However, it is important to note that the current study, while finding a trend, did not find a significant relationship between SRM and BMI. As the sample and effect size were small, the power to detect a significant relationship was limited. This relationship should be examined within a larger sample.

Further, this study did not show a relationship between SRM scores and the health outcomes of HEI, total energy intake, energy expenditure from physical activity, minutes of MVPA, length of sleep, or BF%. These health outcomes all had very small effect sizes less than 0.02, which indicate that the relationships as tested in this study was extremely limited. It would

be anticipated that these variables would remain unrelated to SRM scores even when examined in larger samples due to the very small effect.

The major limitation of this study is the small sample size. With the small sample size, there was limited power to detect significance for small effects. This was seen in particular with BMI as an outcome of weight status. Future research should aim for a larger sample size; doing so would address the statistical power limitation of this study.

Another limitation of the study is the lack of generalizability to young adults. The participant demographics of this study are not truly representative of the sample population. The participants were mostly female, white, non-Hispanic, and receiving higher education. Further, the majority of participants were IT for their chronotype; only four participants were MT, and none were ET. While chronotype is a normal measure (Diaz Morales & Sanchez-Lopez, 2004) indicating that most people are IT, the lack of ET participants limits the generalizability of the results even further. This lack of diversity in gender, race, ethnicity, educational attainment, and chronotype indicates that the results of this study should not be generalized to all young adults between the ages of 18 and 35 years.

One strength of this study is that strong measures were utilized for diet, physical activity and sleep; this increases the reliability of the data collected. For the dietary assessment, the standard method was utilized: three successive daily food records (Biro et al., 2002). These food records did not rely on the participants' recall and were open ended to minimize omitted foods. Further, two dimensional guides were provided to participants to increase accuracy in portion size reporting. For both sleep and physical activity, accelerometers were used in order to quantify the variables of interest. The accelerometers are reliable in laboratory settings for physical activity and have been shown to be similar to overnight sleep study polysomnography (Fruin &

Rankin, 2004; Sharif & Bahammam, 2013). For weight outcomes, body composition was determined using bioelectrical impedance and was reported as percent body fat. Research shows that the foot-to-foot bioelectrical impedance has been comparable to the standard DXA assessment (Goldfield et al., 2006).

Another major strength of this study was the novel use of the SRM as an indicator for entrainment of the CTS, rather than simply looking at the relationship between chronotype and health outcomes. Previous research has not used the SRM within this population to observe how young adults' schedules relate to their health behaviors. The relationship between social rhythms and sleep efficiency provides support for the role that social rhythms can play in one's health. Future research should continue to use the SRM within different populations to better understand behavioral rhythms are related to health outcomes.

In addition to using SRM in future research, it would be recommended to break down specific behaviors for the outcomes of interest. For the current study, data on physical activity were collected such that it was not possible to discern unplanned activity from planned activity. The location or type of activity, whether it be walking, sports, cycling, etc., could not be determined based on accelerometry data alone. Further, the length of each bout of activity and overall patterns of activity were not analyzed for this study. These nuances in physical activity may be related to SRM, such that planned activity or exercise may be correlated to behavioral consistency, and this should be explored by future research. Additionally, eating patterns were not analyzed based on the information collected in the food records; however, these patterns could be of interest in future research with SRM and dietary patterns. There were no analyses conducted in this study for meal and snacking patterns, which could be related to SRM. It is recommended that these aspects be explored in future research with SRM.

Findings from this study indicate that greater consistency in behavioral rhythms is related to higher sleep efficiency. This relationship suggests better entrainment of the CTS in those with a more consistent behavioral schedule. Further, there was a relationship between chronotype and SRM score, as previous research has noted. Future research is needed in larger, more generalizable samples to better understand the relationship between SRM and health outcomes, particularly that of weight status.

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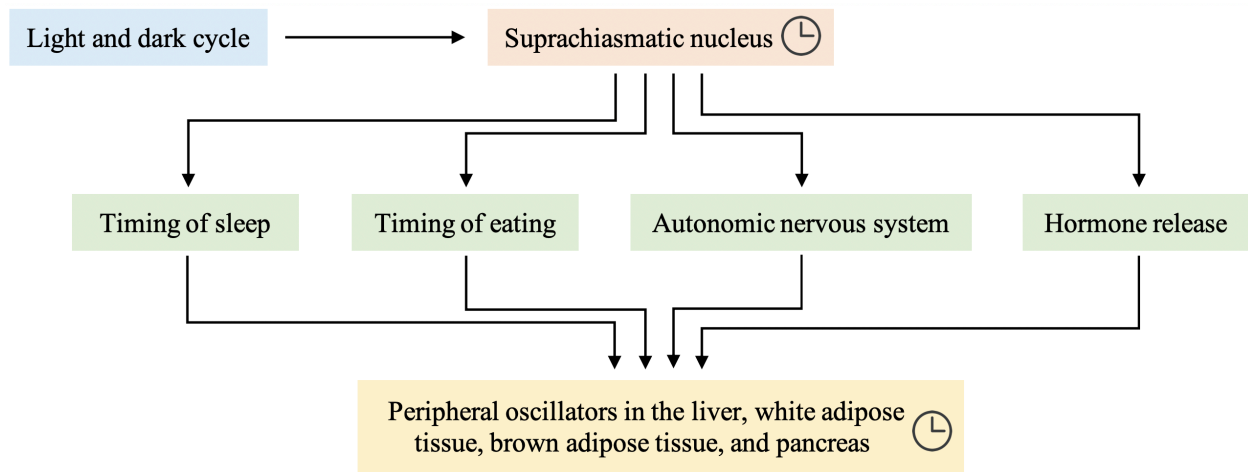
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APPENDICES

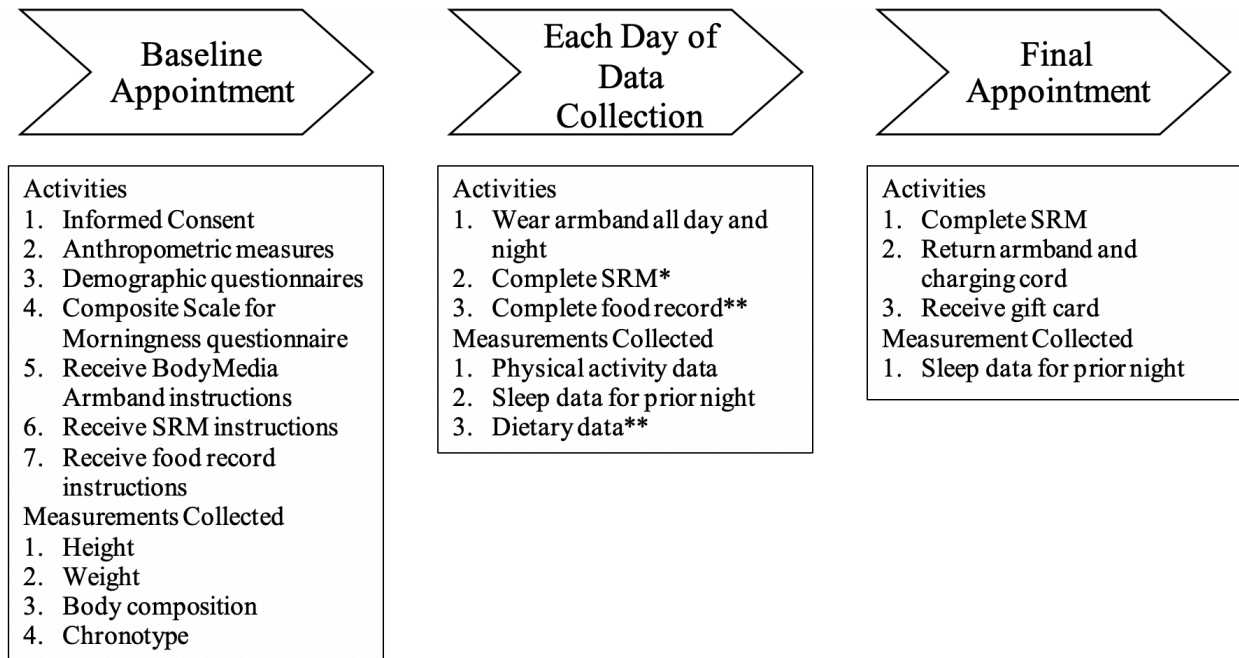
Appendix A: Figures

Figure 1. The Circadian Timing System.



Note. Adapted by permission from Springer Nature Customer Service Centre GmbH: Nature, *Nature Reviews Endocrinology*, Stenvers, D. J., Scheer, F., Schrauwen, P., la Fleur, S. E., & Kalsbeek, A. (2019)

Figure 2. Participant Flow Through the Study.



Note. *The survey sent on day one was to ensure the participant could work the survey; **Food records were collected over three successive days; one weekend day and two weekdays

Appendix B: Consent Form

Consent for Research Participation

Research Study Title: Diet, Physical Activity, and Sleep Habits Study
Researcher(s): Grace Hawkins, University of Tennessee, Knoxville
Hollie Raynor, PhD, RD, LDN, University of Tennessee, Knoxville

Why am I being asked to be in this research study?

We are asking you to be in this research study because you are an adult between the ages of 18 and 35 years, taking classes and/or working, and able to engage in physical activity.

What is this research study about?

The purpose of the study is to observe the diet, physical activity, and sleep habits of young adults.

How long will I be in the research study?

If you agree to be in this study, your participation will last 8 to 14 days and will involve one session at the beginning, one session at the end, and 7 online surveys.

What will happen if I say “Yes, I want to be in this research study”?

If you agree to be in this study, we will ask you to come to the Healthy Eating and Activity Laboratory (HEAL) for 1, 60-minute first session and 1, 30-minute final session. At the first session, your height, weight, and body composition will be measured. You will be asked to complete questions about your demographic information (age, race, education, etc.) and you will complete a survey about your typical sleep habits. You will be given a Body Media Armband, along with instructions for care and use and a charging cord, to wear every day and night over the next week. You will also receive instructions on how to complete an online survey on daily activities and how to complete 3 days of food records. After a week of taking the survey on daily activities, you will return for your final session. At this session, you will return the armband, charging cord, and food records. You will receive feedback on your diet, physical activity, and sleep habits via email within two weeks of completing your participation.

The daily surveys, which will take no more than 5 minutes to complete, about your typical activities will be emailed to you each morning. The surveys should be completed each day by 3 pm. If you do not complete the survey by 2 pm, you will receive a reminder email. You will be asked to wear the Armband for at least 23 hours each day. This means wearing the Armband while sleeping and during the day. Do not wear the Armband when engaging in water activities (bathing or swimming). You will be asked to complete the food records on three consecutive days, two weekdays and one weekend day. It will take about 20 minutes to complete each day of the food record. The daily surveys, armband, and food records will need to be collected during the same week.

What happens if I say “No, I do not want to be in this research study”?

Being in this study is up to you. You can say no now or leave the study later. Either way, your decision won't affect your relationship with the researchers or the University of Tennessee.

What happens if I say “Yes” but change my mind later?

Even if you decide to be in the study now, you can change your mind and stop at any time.

IRB NUMBER: UTK IRB-19-05178-XP

IRB APPROVAL DATE: 07/23/2019

IRB EXPIRATION DATE: 05/01/2020

Participant Initials _____

If you decide to stop before the study is completed, you may contact the HEAL at 865-974-0752 to let us know you would no longer like to participate. You can then schedule a time to return the armband and charging cord. Any of your information already collected for the research study will be returned to you if you request it.

Are there any possible risks to me?

Possible risks of this research study are considered minimal. It is possible that someone could find out you were in this study or see your study information, but we believe this risk is small because of the procedures we use to protect your information. The confidentiality procedures are described later in this form. You may be allergic to the metal in the Armband, but you have been phone screened on this criterion.

Are there any benefits to being in this research study?

We do not expect you to benefit from being in this study. Your participation may help us to learn more about the diet, physical activity, and sleep habits of young adults. We hope the knowledge gained from this study will benefit others in the future.

Who can see or use the information collected for this research study?

We will protect the confidentiality of your information by storing it securely. Only persons conducting the study will have access to your information unless you specifically give permission in writing to do so otherwise.

If information from this study is published or presented at scientific meetings, your name and other personal information will not be used.

We will make every effort to prevent anyone who is not on the research team from knowing that you gave us information or what information came from you. Although it is unlikely, there are times when others may need to see the information that we collect about you. These include:

- People at the University of Tennessee, Knoxville who oversee research to make sure it is conducted properly.
- Government agencies (such as the Office for Human Research Protections in the U.S. Department of Health and Human Services), and others responsible for watching over the safety, effectiveness, and conduct of the research.
- If a law or court requires us to share the information, we would have to follow that law or final court ruling.
- A description of this study will be posted on a public website, <http://ClinicalTrials.gov>, and summary results of this study will be posted on this website at the conclusion of the research. No information that can identify you will be posted.

What will happen to my information after this study is over?

Your research information may be used for future research studies or shared with other researchers for use in future research studies without obtaining additional informed consent from you. If this happens, all of your identifiable information will be removed before any future use or distribution to other researchers.

IRB NUMBER: UTK IRB-19-05178-XP
IRB APPROVAL DATE: 07/23/2019
IRB EXPIRATION DATE: 05/01/2020

Participant Initials _____

Will I be paid for being in this research study?

If you complete all procedures in this study, you will receive a \$25 Amazon gift card at your final session. You will not receive any payment if you withdraw from the study before completing all of the activities.

What else do I need to know?

We may need to stop your participation in the study without your consent if you no longer meet the study's eligibility requirements.

The University of Tennessee does not automatically pay for medical claims or give other compensation for injuries or other problems.

Who can answer my questions about this research study?

If you have questions or concerns about this study, or have experienced a research related problem or injury, contact the researchers:

Grace Hawkins
229 Jessie Harris Building
The University of Tennessee, Knoxville
Knoxville, TN 37996-1920
Phone: (865) 974-0752

Dr. Hollie Raynor
301B Jessie Harris Building
The University of Tennessee, Knoxville
Knoxville, TN 37996-1920
Phone: (865) 974-6259

For questions or concerns about your rights or to speak with someone other than the research team about the study, please contact:

Institutional Review Board
The University of Tennessee, Knoxville
1534 White Avenue
Blount Hall, Room 408
Knoxville, TN 37996-1529
Phone: 865-974-7697
Email: utkirb@utk.edu

STATEMENT OF CONSENT

I have read this form and the research study has been explained to me. I have been given the chance to ask questions and my questions have been answered. If I have more questions, I have been told who to contact. By signing this document, I am agreeing to be in this study. I will receive a copy of this document after I sign it.

Name of Adult Participant

Signature of Adult Participant

Date

Researcher Signature (to be completed at time of informed consent)

I have explained the study to the participant and answered all of his/her questions. I believe that he/she understands the information described in this consent form and freely consents to be in the study.

Name of Research Team Member

Signature of Research Team Member
IRB NUMBER: UTK-IRB-19-05178-AP
IRB APPROVAL DATE: 07/23/2019
IRB EXPIRATION DATE: 05/01/2020

Date

Participant Initials _____

Appendix C: Tables

Table 1. Participant Demographics

	Number	%
Gender		
Female	49	83.1
Male	10	16.9
Current Level of Education		
Freshman	11	18.6
Sophomore	5	8.5
Junior	6	10.2
Senior	11	18.6
Undergraduates in their fifth year or greater	3	5.1
Graduate student	19	32.2
Working, not a student	4	6.8
Marital Status		
Single, never married	51	86.4
Married	3	5.1
Divorced	1	1.7
Not married, living with significant other	4	6.8
Ethnicity		
Not Hispanic or Latino	57	96.6
Hispanic or Latino	2	3.4
Race		
White	42	71.2
Black or African American	8	13.6
Asian	6	10.2
Asian and White	2	3.4
Other	1	1.7

Note. $N = 59$

Table 2. Descriptive Statistics for Health Variables

	Mean	Standard Deviation
Healthy Eating Index	53.6	13.1
Daily Energy Intake (kcal)	1976	661
Daily Energy Expenditure from Physical Activity (kcal)	998	504
Daily Moderate- to Vigorous-Intensity Physical Activity (minutes)	113	62
Sleep Efficiency	80.0%	8.4%
Length of Sleep (hours)	7.0	1.0
Body Mass Index (kg/m ²)	24.3	4.0
Percent Body Fat	26.3%	9.4%

Note. $N = 59$

Table 3. Summary of Hierarchical Regression Analyses for the Relationship between Social Rhythm Metric and Health Variables.

	Beta Coefficient			R	R ²	R ² Change with SRM	Full Model <i>p</i>
	Gender	CSM Type	SRM				
Model 1 – Healthy Eating Index	5.042	-11.776	-0.851	0.277	0.077	0.003	0.218
<i>p-value</i>	0.270	0.095	0.666			0.666	
Model 2 – Energy Intake	-883.673	35.009	33.341	0.506	0.256	0.002	0.001
<i>p-value</i>	<0.001	0.912	0.709			0.709	
Model 3 – Energy Expenditure from Physical Activity	-2551.037	0.268	151.235	0.457	0.209	0.004	0.005
<i>p-value</i>	<0.001	1.000	0.606			0.606	
Model 4 – Minutes of Moderate- to Vigorous-Intensity Physical Activity	-27.079	-4.983	-0.041	0.164	0.027	<0.001	0.678
<i>p-value</i>	0.223	0.883	0.997			0.997	
Model 5 – Sleep Efficiency	6.462	-0.087	3.141	0.464	0.215	0.106	0.004
<i>p-value</i>	0.019	0.983	0.009			0.009*	
Model 6 – Length of Sleep	-0.168	0.235	0.130	0.131	0.017	0.013	0.810
<i>p-value</i>	0.640	0.670	0.406			0.406	
Model 7 – Body Mass Index	0.837	-0.680	-0.894	0.207	0.043	.038	0.489
<i>p-value</i>	0.551	0.752	0.145			0.145	
Model 8 – Percent Body Fat	13.804	-0.048	-0.871	0.557	0.310	0.006	<0.001
<i>p-value</i>	<0.001	0.991	0.475			0.475	

Note. *N* = 59; Composite Scale for Morningness (CSM); Social Rhythm Metric (SRM); For each model, Gender and CSM Type were force entered into the first block, and SRM was added to the second block such that R² Change indicates the impact of the SRM score on the health variable of interest; **p* < 0.025

Table 4. Pearson Correlations between Social Rhythm Metric and Health Variables.

		Social Rhythm Metric	Healthy Eating Index	Energy Intake	Energy Expenditure from PA	Minutes of MVPA	Sleep Efficiency	Length of Sleep	Body Mass Index	Percent Body Fat
Social Rhythm Metric	Pearson	1	0.009	-0.001	0.025	-0.01	.361**	0.096	-0.184	-0.035
	Sig.		0.945	0.993	0.85	0.942	0.005	0.47	0.162	0.79
Healthy Eating Index	Pearson	0.009	1	-0.044	-0.164	-0.096	.268*	0.227	-0.145	-0.05
	Sig.	0.945		0.739	0.215	0.471	0.04	0.084	0.275	0.707
Energy Intake	Pearson	-0.001	-0.044	1	.433**	0.212	-0.122	0.154	0.165	-0.09
	Sig.	0.993	0.739		0.001	0.106	0.357	0.244	0.211	0.497
Energy Expenditure from PA	Pearson	0.025	-0.164	.433**	1	.859**	0.13	-0.094	-0.137	-.345**
	Sig.	0.85	0.215	0.001		<0.001	0.328	0.481	0.301	0.007
Minutes of MVPA	Pearson	-0.01	-0.096	0.212	.859**	1	0.141	-0.191	-0.211	-.332*
	Sig.	0.942	0.471	0.106	<0.001		0.287	0.148	0.109	0.01
Sleep Efficiency	Pearson	.361**	.268*	-0.122	0.13	0.141	1	.294*	-.327*	-0.069
	Sig.	0.005	0.04	0.357	0.328	0.287		0.024	0.011	0.602
Length of Sleep	Pearson	0.096	0.227	0.154	-0.094	-0.191	.294*	1	-0.13	-0.067
	Sig.	0.47	0.084	0.244	0.481	0.148	0.024		0.326	0.612
Body Mass Index	Pearson	-0.184	-0.145	0.165	-0.137	-0.211	-.327*	-0.13	1	.722**
	Sig.	0.162	0.275	0.211	0.301	0.109	0.011	0.326		<0.001
Percent Body Fat	Pearson	-0.035	-0.05	-0.09	-.345**	-.332*	-0.069	-0.067	.722**	1
	Sig.	0.79	0.707	0.497	0.007	0.01	0.602	0.612	<0.001	

Note. N = 59; MVPA, at least moderate-intensity physical activity; Sig., two-tailed significance; ** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed)

Appendix D: Social Rhythm Metric

Each question appears individually on the screen. If the participant indicates that they did not complete an activity the previous day, then the survey takes them to the next activity. If they indicate that they did complete the activity, then the survey prompts them to enter the time of the activity.

1. Did you get out of bed today?
 - a. If “Yes” is selected, they are taken to #2
 - b. If “No” is selected, they are taken to #3
2. What time did you get out of bed?
 - a. Hour, minute, and am/pm drop-down options
3. Did you have contact with another person today?
 - a. If “Yes” is selected, they are taken to #4
 - b. If “No” is selected, they are taken to #5
4. What time did you have your first contact with another person?
 - a. Hour, minute, and am/pm drop-down options
5. Did you have a beverage today?
 - a. If “Yes” is selected, they are taken to #6
 - b. If “No” is selected, they are taken to #7
6. What time did you have your first beverage?
 - a. Hour, minute, and am/pm drop-down options
7. Did you have breakfast today?
 - a. If “Yes” is selected, they are taken to #8
 - b. If “No” is selected, they are taken to #9

8. What time did you have breakfast?
 - a. Hour, minute, and am/pm drop-down options
9. Did you go outside today?
 - a. If “Yes” is selected, they are taken to #10
 - b. If “No” is selected, they are taken to #11
10. What time did you go outside for the first time?
 - a. Hour, minute, and am/pm drop-down options
11. Did you engage in work, school, housework, family care, or volunteer activities today?
 - a. If “Yes” is selected, they are taken to #12
 - b. If “No” is selected, they are taken to #13
12. What time did you start work, school, housework, family care, or volunteer activities?
 - a. Hour, minute, and am/pm drop-down options
13. Did you have lunch today?
 - a. If “Yes” is selected, they are taken to #14
 - b. If “No” is selected, they are taken to #15
14. What time did you have lunch?
 - a. Hour, minute, and am/pm drop-down options
15. Did you take a nap today?
 - a. If “Yes” is selected, they are taken to #16
 - b. If “No” is selected, they are taken to #17
16. What time did you take a nap?
 - a. Hour, minute, and am/pm drop-down options
17. Did you have an afternoon snack or drink today?

- a. If “Yes” is selected, they are taken to #18
 - b. If “No” is selected, they are taken to #19
18. What time did you have an afternoon snack or drink?
- a. Hour, minute, and am/pm drop-down options
19. Did you have dinner today?
- a. If “Yes” is selected, they are taken to #20
 - b. If “No” is selected, they are taken to #21
20. What time did you have dinner?
- a. Hour, minute, and am/pm drop-down options
21. Did you do any physical exercise today?
- a. If “Yes” is selected, they are taken to #22
 - b. If “No” is selected, they are taken to #23
22. What time did you do physical exercise?
- a. Hour, minute, and am/pm drop-down options
23. Did you watch an evening screen-based (TV, streaming) program today?
- a. If “Yes” is selected, they are taken to #24
 - b. If “No” is selected, they are taken to #25
24. What time did you watch an evening screen-based (TV, streaming) program?
- a. Hour, minute, and am/pm drop-down options
25. Did you watch another screen-based (TV, streaming) program today?
- a. If “Yes” is selected, they are taken to #26
 - b. If “No” is selected, they are taken to #27
26. What time did you watch another screen-based (TV, streaming) program?

- a. Hour, minute, and am/pm drop-down options
27. Did you return home for a last time today?
- a. If “Yes” is selected, they are taken to #28
 - b. If “No” is selected, they are taken to #29
28. What time did you return to your home for the last time of the day?
- a. Hour, minute, and am/pm drop-down options
29. What time did you go to bed?
- a. Hour, minute, and am/pm drop-down options
30. Optional: Other activity 1?
- a. Hour, minute, and am/pm drop-down options
31. What was this activity?
- a. Blank text box response
32. Optional: Other activity 2?
- a. Hour, minute, and am/pm drop-down options
33. What was this activity?
- a. Blank text box response

Appendix E: Composite Scale for Morningness

Please *check* the response for *each* item that best describes *you*.

1. Considering only your own “feeling best” rhythm, at what time would you get up if you were entirely free to plan your day?
☐ (5) 5:00 - 6:30 a.m.
☐ (4) 6:30 - 7:45 a.m.
☐ (3) 7:45 - 9:45 a.m.
☐ (2) 9:45 - 11:00 a.m.
☐ (1) 11:00 a.m. – 12:00 noon
2. Considering only your own “feeling best” rhythm, at what time would you go to bed if you were entirely free to plan your evening?
☐ (5) 8:00 - 9:00 p.m.
☐ (4) 9:00 - 10:15 p.m.
☐ (3) 10:15 p.m. - 12:30 a.m.
☐ (2) 12:30 - 1:45 a.m.
☐ (1) 1:45 a.m. – 3:00 a.m.
3. Assuming normal circumstances, how easy do you find getting up in the morning?
☐ (1) Not at all easy
☐ (2) Slightly easy
☐ (3) Fairly easy
☐ (4) Very easy
4. How alert do you feel during the first half hour after having awakened in the morning?
☐ (1) Not at all alert
☐ (2) Slightly alert
☐ (3) Fairly alert
☐ (4) Very alert
5. During the first half hour after having awakened in the morning, how tired do you feel?
☐ (1) Very tired
☐ (2) Fairly tired
☐ (3) Slightly tired
☐ (4) Not at all tired
6. You have decided to engage in some physical exercise. A friend suggests that you do this one hour twice a week and the best time for him is 7:00-8:00 am. Bearing in mind nothing else but your “feeling best” rhythm, how do you think you would perform?
☐ (4) Would be in good form
☐ (3) Would be in reasonable form
☐ (2) Would find it difficult
☐ (1) Would find it very difficult

7. At what time in the evening do you feel tired and as a result, in need of sleep?
- ☐ (5) 8:00 - 9:00 p.m.
 - ☐ (4) 9:00 - 10:15 p.m.
 - ☐ (3) 10:15 p.m. – 12:30 a.m.
 - ☐ (2) 12:30 - 1:45 a.m.
 - ☐ (1) 1:45 a.m. – 3:00 a.m.
8. You wish to be at your peak performance for a test, which you know is going to be mentally exhausting and lasting for two hours. You are entirely free to plan your day, and considering only your own "feeling best" rhythm, which ONE of the four testing times would you choose?
- ☐ (4) 8:00 - 10:00 a.m.
 - ☐ (3) 11:00 a.m. - 1:00 p.m.
 - ☐ (2) 3:00 - 5:00 p.m.
 - ☐ (1) 7:00-9:00 p.m.
9. One hears about "morning" and "evening" type people. Which ONE of these types do you consider yourself to be?
- ☐ (4) Definitely a morning type
 - ☐ (3) More a morning than an evening type
 - ☐ (2) More an evening than a morning type
 - ☐ (1) Definitely an evening type
10. When would you prefer to rise (provided you have a full day's work – 8 hours) if you were totally free to arrange your time?
- ☐ (4) Before 6:30 a.m.
 - ☐ (3) 6:30 – 7:30 a.m.
 - ☐ (2) 7:30 - 8:30 a.m.
 - ☐ (1) 8:30 a.m. or later
11. If you always had to rise at 6:00 am, what do you think it would be like?
- ☐ (1) Very difficult and unpleasant
 - ☐ (2) Rather difficult and unpleasant
 - ☐ (3) A little unpleasant but no great problem
 - ☐ (4) Easy and not unpleasant
12. How long a time does it usually take before you "recover your senses" in the morning after rising from a night's sleep?
- ☐ (4) 0-10 minutes
 - ☐ (3) 11-20 minutes
 - ☐ (2) 21-40 minutes
 - ☐ (1) More than 40 minutes
13. Please indicate to what extent you are a morning or an evening *active* individual?
- ☐ (4) Very morning active (morning alert & evening tired)
 - ☐ (3) To some extent, morning active
 - ☐ (2) To some extent, evening active
 - ☐ (1) Very evening active (morning tired & evening alert)

VITA

Grace Hawkins is originally from Nashville, Tennessee. For undergraduate studies, she attended Miami University in Oxford, Ohio. She graduated in 2018 with a Bachelor of Arts in Psychology and a Bachelor of Science in Nutrition Dietetics. While at Miami University, she was highly involved with the service fraternity Alpha Phi Omega. She worked at the Wilks Leadership Institute on campus and in Dr. April Smith's Research on Eating Disorders and Suicidality laboratory. She also completed an undergraduate honors thesis in psychology titled *The Body Project as an Intervention to Reduce Risk Factors for Suicidal Ideation*.

Following undergraduate school, Grace pursued her Master of Science in Public Health Nutrition and Dietetic Internship at UTK. While at UTK, she co-developed a Facilitator Guide for a 12-week nutrition education course to be taught to groups at Peninsula Health. Grace volunteered to work as an educator for the Knox County Health Department Nutrition Education and Activity Training (NEAT) Program. Grace worked as a graduate research assistant in Dr. Hollie Raynor's Healthy Eating and Activity Laboratory (HEAL). As a graduate research assistant, she worked on the NIH-funded grant for an 18-month family-based childhood overweight and obesity treatment program. For this research study, she helped to develop protocols for assessments and education manuals for the child and caregiver participants. As a part of her work in the HEAL, Grace was able to enhance her professional writing skills and counseling and weight management knowledge for both adults and children. Thus, Grace seeks to work with either adults or children for weight management and lifestyle change following graduation. Grace will complete her Dietetic Internship and Masters in August of 2020.